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DECLARATION

I, Peter Johnson, BA MITI, of Beacon House, 49 Linden Road, Gosforth, Newcastle upon Tyne, NE3 4HA, hereby certify that to the best of my knowledge and belief the following is a true translation made by me, and for which I accept responsibility, of
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Signed this 23rd day of May 2005

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Method of determining the living character of an element carrying a fingerprint

The present invention concerns a method of checking the living character of a finger by means of a fingerprint sensor. The invention also confirm the fingerprint sensor for implementing this method.

In general terms, any protected access becomes accessible to an authorised person by a means that he alone possesses. One of the means of limiting access to a person is to require the fingerprint of this person. The image of the fingerprint of a person is obtained by a fingerprint sensor. Once the image of the print is obtained by the sensor, it is transmitted to an image processing unit that compares the image obtained with a bank of print images so as to check that the print taken by the sensor is known. Recognition of the print by the image processing unit then opens up, to the person to whom the print corresponds, access to that which he seeks.

It has been found that, although identification by fingerprints is a known method, it still poses problems. This is because there are many forgers who attempt to deceive fingerprint sensors with imitations. The artifices in particular used are false fingers.

In order to thwart such forgers, several methods have been proposed for determining whether the element carrying the fingerprint is living. Certain methods use optical means. This is for example the case with the document US-A-5 719 950, which describes a method consisting of measuring biometric parameters such as the oxygen level in the blood, the

temperature of the skin, etc. The document US-A-5 737 439 describes an optical measurement system for detecting blood flow by means of two wavelengths. Other methods consist of making electrical measurements. This is the case with the document JP-A-11197135, which describes the measurement of variations in capacitance between two electrodes, and the document US-A-5 953 441, which describes a device for measuring the complex impedance of the finger and comparing it with reference curves which are a function of frequency.

It has been found that, through the methods already known, that the measurement of the impedance of the finger is one of the methods best suited to checking the living character of a finger, but which still sometimes happens to be deceived by imitations.

The aim of the invention is therefore to propose a method of checking the living character of a finger which provides discrimination between a living finger and an imitation with certainty.

To this end, the invention concerns a method of determining the living character of an element carrying a fingerprint, consisting of making impedance measurements at various points on the said element by means of electrodes. The method is characterised in that it consists of determining whether the said impedance measurements satisfy a law of variation of the impedance measured by the said electrodes according to the surface area of the said electrodes covered by the said element such that $Z = f_{Dt}(S)$.

According to another characteristic of the invention, the method consists of measuring the impedance between two first

electrodes with a predetermined surface area, measuring the impedance between two second electrodes with a predetermined surface area and checking that the points defined by the impedance and surface area values corresponding to the first and second electrodes belong to the same curve satisfying the said variation law.

According to another characteristic of the invention, the method consists, firstly, of making a first measurement of impedance between two first electrodes with a predetermined surface area and determining the curve satisfying the said variation law, and then secondly making a second measurement of impedance between two second electrodes with a predetermined surface area and checking that the point defined by the impedance and surface area values corresponding to the second electrodes belong to an area of tolerance situated around the predefined curve.

Advantageously, the said second impedance measurement is made randomly between two electrodes of the same size or between two electrodes of different sizes.

According to another characteristic of the invention, the said second impedance measurement is carried out alternately between two electrodes of the same size or between two electrodes of different sizes.

The present invention also concerns a fingerprint sensor making it possible to determine the living character of an element carrying a fingerprint. The sensor according to the invention is characterised in that it comprises at least two pairs of electrodes with different surface areas.

According to another characteristic of the invention, one of the said pairs of electrodes is composed of two small electrodes close together, designed to allow a local measurement of the impedance.

According to another characteristic of the invention, the said sensor comprises a first set of four single-piece electrodes with identical surface areas and a second set of two electrodes in the form of intersecting combs with identical surface areas.

According to another characteristic of the invention, the said sensor comprises an optical system designed to produce an image of the print and to determine the surface area of the measuring electrodes not entirely covered by the fingerprint.

The characteristics of the invention mentioned above as well as others will emerge more clearly from a reading of the following description of an example embodiment, the said description being given in relation to the accompanying drawings, amongst which:

Fig. 1 depicts a view in section of a fingerprint sensor according to the invention on which an element carrying a fingerprint is placed;

Fig. 2a depicts a schematic plan view of a fingerprint sensor whose electrodes are completely covered by a print;

Fig. 2b depicts a schematic plan view of a fingerprint sensor whose electrodes are partially covered by a print;

Fig. 3 depicts a law of variation for the impedance measured between two electrodes as a function of the surface area of

these electrodes;

Fig. 4 depicts a first embodiment with four electrodes of a print sensor according to the invention;

Fig. 5 depicts a second embodiment with six electrodes of a print sensor according to the invention; and

Figs. 6 and 7 depict third and fourth embodiments with eight electrodes of a print sensor according to the invention.

The invention concerns a method of checking the living character of an element carrying a fingerprint by the measurement of impedance Z thereof. It should be noted in the following description that impedance measurement means both the measurement of impedance Z in itself and measurements of the type measuring resistance, capacitance, inductance, etc. The measurement of the impedance Z is carried out, as depicted in Fig. 1, by a fingerprint sensor 1 placed in contact with the element carrying the print, here represented by a finger D. An optical system SO is placed at the base of the sensor so as to produce an image of the print. The fingerprint sensor 1 according to the invention comprises a plate 10 of transparent material, for example glass or transparent plastics material, making the photographing of the print of the finger D optically possible. On the surface 11 of this plate 10 there are disposed electrodes Ei and Ej between which an impedance Zij is measured. The measurement of the impedance Zij between the electrodes Ei, Ej is made possible by virtue of conductive transparent connections 20. These connections 20, also placed in contact with the plate 10, must necessarily be conductive and transparent so as to allow the sensor 1 to fulfil both its function of image sensor and its function of checking the

living character of the finger. The transparency of the connections 20 is preferably obtained by a vacuum deposition of a very fine layer of material, preferably ITO (Indium Tin Oxide), with a thickness of less than one micrometre. The whole of the surface of the sensor 1, with the exception of the electrodes Ei, Ej, is covered with a layer of insulating material 30 making it possible to offer only the electrodes Ei, Ej for contact with the finger D.

Figs 2a and 2b depict a plan view of a fingerprint sensor 1 according to the invention. In these Figs, the sensor 2 comprises two electrodes Ea, Eb, with a small surface area and two electrodes Ec, Ed with a larger surface area. These four electrodes are designed to make it possible to measure in pairs the impedance Z of the finger D which covers them with its print 4. Advantageously, the impedance Zab between the two smallest electrodes Ea and Eb is measured, and then the impedance Zed between the two largest electrodes Ec and Ed.

Between Fig. 2a and Fig. 2b, the surface area S of the electrodes covered by the print 4 is different. This difference may stem from the difference in print between two fingers or the difference in pressure exerted on the sensor 1 by one and the same finger. In general terms, it will be noted that the surface Sij in question preferably corresponds to the smaller surface of the two surfaces of the electrodes Ei and Ej covered by the print 4 of the finger D. In other words, if, as depicted in Fig. 2a, the print 4 of the finger D entirely covers the electrodes Ec and Ed, the surface Scd in question will advantageously correspond to the surface of one of the electrodes Ec or Ed. If, as depicted in Fig. 2b, the print 4 does not entirely cover the electrodes Ec and Ed, the surface Scd in question will then advantageously correspond to the

smaller of the areas *Ac* or *Ad* covered by the print 4 of the finger D. These areas *Ac* and *Ad*, which are hatched in Fig. 2b, are for example determined by means of the optical system SO placed under the sensor 1. Likewise, if the measurement of impedance Z is made between a small electrode Ea and a larger electrode Ec and the print 4 of the finger D does not entirely cover the electrodes as depicted in Fig. 2b, then the surface Sac in question will advantageously be the smaller surface taken between the surface Sa of the electrode Ea and the area *Ac* of the electrode Ec.

The method according to the invention is based on a statistical law of variation of the impedance Z measured between two electrodes according to the surface area S of these same electrodes. This variation law is depicted for a given figure D at a given time t in the form of a graph in Fig. 3. The curve shown in this Fig. is such that the impedance Z is proportional to the surface area S: $Z = f_{Dt}(S)$.

For a given finger D at a given time t, there exists only one curve. Based on this finding, an impedance Zab between the two small electrodes Ea and Eb is first measured. Knowing moreover the surface area Sab of the small electrodes Ea, Eb, the coordinates of a point Pab of one of the curves satisfying the variation law described above are therefore known. From this first measurement, the curve C corresponding to the finger D that satisfies the law is then determined.

Secondly it is checked that the impedance Z is constant over the whole of the finger D. For this purpose, the impedance Zcd between the two large electrodes Ec and Ed is measured. Knowing there also the surface area Scd of the large electrodes Ec and Ed, it is possible to place a point Pcd on the graph in

Figure 3. If the point Pcd obtained by this second measurement is situated in an area of tolerance T surrounding the curve C, it will be considered that the law is satisfied for this second point Pcd and therefore that the finger is living. The area of tolerance T corresponds approximately to a standard deviation b around the curve C such that T = 2b. This standard deviation b varies according to statistical data.

It should be noted that it would also be possible to make the measurements of impedance Zab between the small electrodes and Zcd between the large electrodes at the same time, and then check that the points Pab and Pcd corresponding to the measurements made belong to the same curve.

The method is put into practice through the use of a fingerprint sensor 1. Several embodiments of the sensor 1 according to the invention are proposed. These various embodiments are depicted in Figs. 4, 5, 6 and 7. Fig. 4 depicts a first embodiment of the fingerprint sensor according to the invention. In this first embodiment, the sensor 1 comprises two small electrodes Ea, Eb and two large electrodes Ec, Ed, that is to say two sets of two electrodes with identical surface areas within the same assembly. Each of the electrodes is connected by a connection 20, preferably made from ITO (Indium Tin Oxide), to an apparatus for measuring the impedance Z. Thus, in a first embodiment of the sensor, the method described above is implemented and it is checked by this means that the finger D is living.

One essential character of the invention satisfied for all the embodiments of the sensor is the random character of the impedance measurements. Random character means the possibility of making impedance measurements both between two small

electrodes and between a small electrode and a large electrode and being able to reverse the electrodes used for measuring the impedance so as to thwart any forgers who may have understood the functioning of the sensor. Using the sensor depicted in Fig. 4, a third impedance measurement can therefore be carried out, for example alternately for one finger out of two, between the electrodes Ec and Ea and then between the electrodes Ed and Eb. This third measurement confirms the second measurement.

Fig. 5 depicts a second embodiment of a fingerprint sensor according to the invention comprising six measuring electrodes. Amongst these six electrodes, there are four large electrodes Ec, Ed, Ee and Ef and two small electrodes Ea and Eb, that is to say a first set of four single-piece electrodes with identical surface areas and a second set of two electrodes in the form of intersecting combs with identical surface areas. The two small electrodes are each composed of two electrode parts electrically connected by a bead of conductive material advantageously made from ITO. The two parts of the same electrode are separated by a part of the other electrode so as to measure a very localised precise impedance. The impedance measurements are made in the following manner. The impedance Zab between the small electrodes Ea, Eb is measured and second and third impedances are measured, either between two of the large electrodes, for example between the electrodes Ec and Ee (Zce) and then Ef and Ed (Zfd) if these electrodes are covered by the finger D, or in the contrary case between a large electrode and a small electrode, for example between Ec and Ea (Zac) and between Ee and Eb (Zeb).

In the third and fourth embodiments of the sensor according to the invention, the measuring electrodes are eight in number, that is to say four large electrodes Ec, Ed, Ee and Ef and four

small electrodes Ea, Eb, Eg and Eh. These embodiments are depicted in Figs. 6 and 7. In the third embodiment, the sensor 1 comprises two sets of four single-piece electrodes with identical surface areas within each set, whilst in the fourth embodiment the sensor 1 comprises a first set of four single-piece electrodes with identical surface areas and a second set of two single-piece electrodes with identical surface areas and a third set of two electrodes in the form of intersecting combs with identical surface areas. The measurements of impedance Z for each of the embodiments are made in an identical manner. The impedances Zah and Zbg are measured between the small electrodes Ea, Eh and Eb, Eg and either the impedance Zce is measured if the finger covers the corresponding electrodes or if such is not the case Zdb or Zfa or Zab. It is also possible to measure the impedance Zfd if the corresponding electrodes are covered by the finger D, otherwise Zcb or Zeg or Zgh is measured.